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THE MECHANICS OF PUBLIC TRANSPORTATION: SUPPLIER ACTION, RIDER REACTION AND VICE VERSA

by

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ABSTRACT

This paper describes how a regulated transit authority, the Montreal Urban Community Transit Commission, determines the main dimensions of the service it supplies to potential users: walking time to a stop, waiting time, travel time and seat-mileage or capacity. Measures of the impact of these service levels, and of other factors, on the use of transit and car modes are also provided. The reciprocal determination of transit ridership and transit service levels is emphasized.

RÉSUMÉ

Nous présentons dans cet article une description du processus par lequel le responsable du transport en commun à Montréal, la Commission de Transport, établit les principaux éléments du service offert au public: le temps de marche, les temps d'attente et de transport, et la capacité (sièges-milles). L'effet de ces niveaux de service ainsi que d'autres variables sur l'utilisation du transport public et de l'automobile y sont aussi examinés. Nous soulignons en particulier la détermination réciproque des clientèles et des niveaux du transport public.

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HORS-TEXTE

Ladies and gentlemen,

When I received the invitation to give this Distinguished Philips lecture, I feared for a moment that its name connected it with a dubious construct of macroeconomic analysis, called the Phillips curve, which assumes that, for the same amount of money, people can be manipulated into working harder. I was quickly reassured that the person at the origin of this lecture held no such belief and for that reason spelled his name with a single $\underline{\ell}$.

An even greater worry was that the lecture, in keeping with the tradition, had to be distinguished. I was saved this time by the Haverford motto, "non doctior sed meliore doctrina imbutus", which implied that I did not have to be learned as long as I was filled with good intentions. I will therefore ask this audience to accept my state of mind as wager and proceed with the lecture which I am truly honored and pleased to give.

INTRODUCTION*

Urban public transportation has recently come to the forefront of policy debates. The issues involved in deciding how much of it is desirable, and at what price, have the interesting feature that everyone has strong views on them. In consequence, it appears harder to obtain a public consensus in this area than,for instance, on yet another reform of the international monetary system. Indeed, the public transportation debate evokes immediate problems of economic efficiency, quality of life and redistributive justice which, like ice hockey, generate heated debates.

Our analysis will centre on a narrow aspect of the quandary, namely on how a large public transportation supplier *works* on a short-horizon basis and on what immediate *impact* his behavior may have. For this purpose, we will examine the Montreal system considered as a whole. Although the numerical results we will present are specific to that North American city and pertain to the period December 1956 to December 1971, they can be indicative of situations elsewhere. Their validity depends on limitations of data and analytical techniques more fully explained elsewhere (Gaudry 1977b).

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REGULATED TRANSIT SUPPLY BEHAVIOR

In the short-run, a transit supplier must make the best possible use of the available infrastructure of roads and underground tunnels. His technology being given, what does he supply to the public? There are four important dimensions of the service over which he has some control or at least some influence. These are: the time people have to spend *walking* to reach stops or stations, the time they have to *wait* for a vehicle, the time spent in the vehicle or *travel time* proper and the *capacity* or amount of space made available on vehicles. We shall say nothing about the determinaiton of vehicle comfort and the fare. We shall summarize how the Montreal Urban Community Transit Commission (henceforth MUCTC), a regulated public monopoly, influences these crucial four dimensions of public transportation supply.

A. Walking or access time

When the distribution of economic activities in an urban area is fixed of varies very slowly, walking time to public transportation depends primarily on the density of routes or circuits over the area in question. The MUCTC continually extends the length of its routes in such a way that, in the territory served, all possible origins and destinations be within one eight of a mile from a line and one quarter of a mile from a stop. The access time is therefore the result of a policy decision and, taking a bird's eye view, approximately constant over time.

B. Waiting time

Once the length of routes is decided, and considering for the moment vehicle speeds as given, the next crucial decision is the number of vehicles

to be put in service during each period. For a producer who makes zero profit, the number of vehicles put in service will tend to increase when revenues increase and, other things being equal, decrease when production costs rise. These changes in numbers of vehicles on the road will imply proportional changes in service frequency or in waiting time if speeds are given and non proportional changes in waiting time if speeds vary as a consequence of variations in the number of transit vehicles on the circuits or for other reasons.

During the period we analyzed, namely until the early seventies, it can be estimated that each increase of the average fare by ten cents decreased the average waiting time per trip by 3 seconds. This represents a 2% improvement in waiting time for each 100% increase in fares. In this case, plotting fare against waiting time on a graph would have given a line such as that which is found in Figure 1. During the same period, a 10% increase

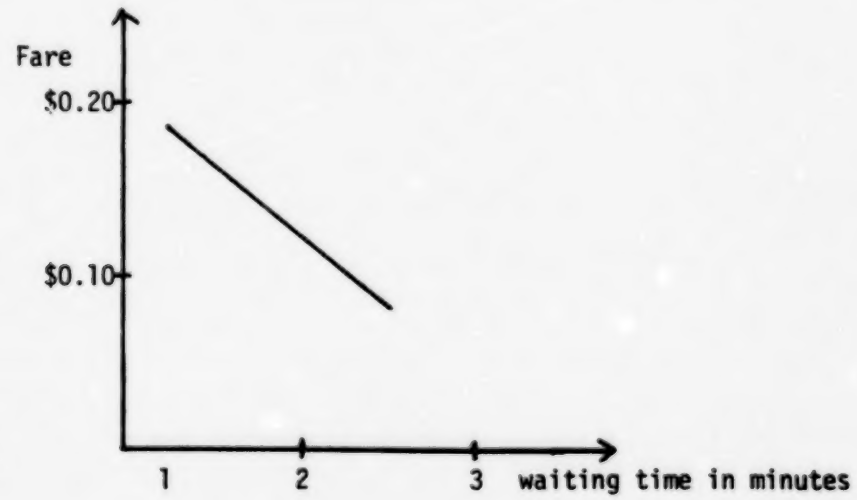

Figure 1. The supply of waiting time

in ridership improved waiting time by 6 seconds and each million dollars in annual operating subsides by three quarters of a second. By contrast, each ten cent increase in the hourly wage rate of bus drivers led to an increase of the average waiting time of 2.5 seconds: this represents a 2.5% increase in waiting time for each 100% increase in wages.

But technology has not been constant. Changes in the firm's cost structure due to the abandonment of trolley buses and concomitant changes in vehicle speeds improved the waiting time by 7.6 seconds; similar changes due to the Metro improved it by 28 seconds.

It can also be calculated that each 10-mile increase in the length of bus routes caused the average user to wait 2 seconds more for a vehicle. Among the weather variables, a doubling of the monthly rainfall increased waiting time by 1.5 seconds.

C. In-vehicle travel time

In-vehicle travel time is inversely related to speed. And speed depends on factors like how many transit vehicle of each type are put in service, how many people use them, how many cars use the roads, and on other factors such as the weather and the management of the road network. We have not been able to isolate the impact of congestion created by the buses themselves (the speed of the Metro is constant) and by car usage due to unreliable data. We have however estimated that, always at the margin, a 25% increase in the number of passengers increased the average travel time by about 2% and that substituting buses for trolley buses decreased it by 12 seconds while the introduction of the Metro decreased it by 20% or 4 minutes and 23 seconds.

D. Capacity

With a given technology, the effective capacity of a transit system depends on realized speeds: a sudden increase of transit vehicle speeds will, other things being equal, increase seat-mileage supplied. In that sense, capacity is partly beyond the control of the transit supplier.

The determination of many of the dimensions of public transportation services then clearly depends on ridership levels: higher usage of transit facilities leads to improvements in waiting time, to slower realized speeds and to lower capacity. Can the transit authority influence these ridership levels?

IMPACT OF TRANSIT FARE AND SERVICE ON URBAN TRAVEL

The transit suppliers actions influence both the demand for its own services and the demand for the use of the automobile. These impacts are shown in Table 1 where elasticities of demand summarize the average per-

Table 1

Transit and car usage elasticities of demand and time prices*

Demand for	Transit factors		
	Fare	Wait time	Travel time
Transit by adults**	-.18	-.16 (2.24)	-.49 (1.25)
Transit by children**	-.44	-.21 (0.44)	-.16 (0.06)
Gasoline	.10	.20 (4.90)	.11 (0.48)

* Numbers in parentheses are time prices in dollars per hour.

** Updated version of results presented in Gaudry (1977a).

centage response of demand following a percentage change in fare and service levels. We note that all travellers give a higher value to transit wait-time and to transit travel time but that car users evaluate transit wait time more than twice as much as transit users whilst the opposite is true of travel time. Transit suppliers have a considerable impact on the use of both travel modes.

OTHER DETERMINANTS OF TRAVEL AND MODE CHOICE DECISIONS

There are of course other determinants of urban travel and mode choice decisions than transit fare and service levels. Table 2 shows the

Table 2

Other transit and car usage elasticities of demand

Demand for	Factors				
	C.P.I.	Income	Employment	Shopping	Schooling
Transit by adults	.10	.52	.22	.06	.01
Transit by children	.54	.65	n/c	.11	.34
Gasoline	.06	.35	.62	.20	-.11

elasticity of demand for each mode with respect to the consumer price index, real average earnings and the level of basic economic activities. We note that both travel modes are substitutes for other goods (85% of the C.P.I. consists of non-transportation goods) and that both are superior commodities. Transit usage is more sensitive to the C.P.I. and to income than car usage. By contrast, car usage is more sensitive to changes in most basic economic activities than transit usage: results in the employment and shopping

columns imply decreasing transit market shares for these trip purposes.

Table 3 shows the direction of the impact on each market of excessively warm or cold temperature, rainfall, snowfall and cumulative snowfall. In interpreting these results, one should remember that both travel modes can gain simultaneously if pedestrian trips decrease.

Table 3

Directional impact of weather factors on transit and car usage

Demand for	Weather factors			
	Too warm or cold temperature	Rainfall	Snowfall	Cumulative snowfall
Transit by adults	+	-	+	+
Transit by children	+	-	-	+
Gasoline	-	-	+	-

CONCLUSION

These calculations give a reasonable idea of the determinants of the usage of each mode in a large urban area and of the way in which a large transit supplier operates. These results are not all exact or of the same degree of statistical significance. They are useful to discussions of policy options where it is important to have an idea of the likely reactions of both consumers and suppliers to eventual decisions, lest one opted for unfeasible objectives.

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